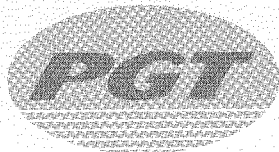


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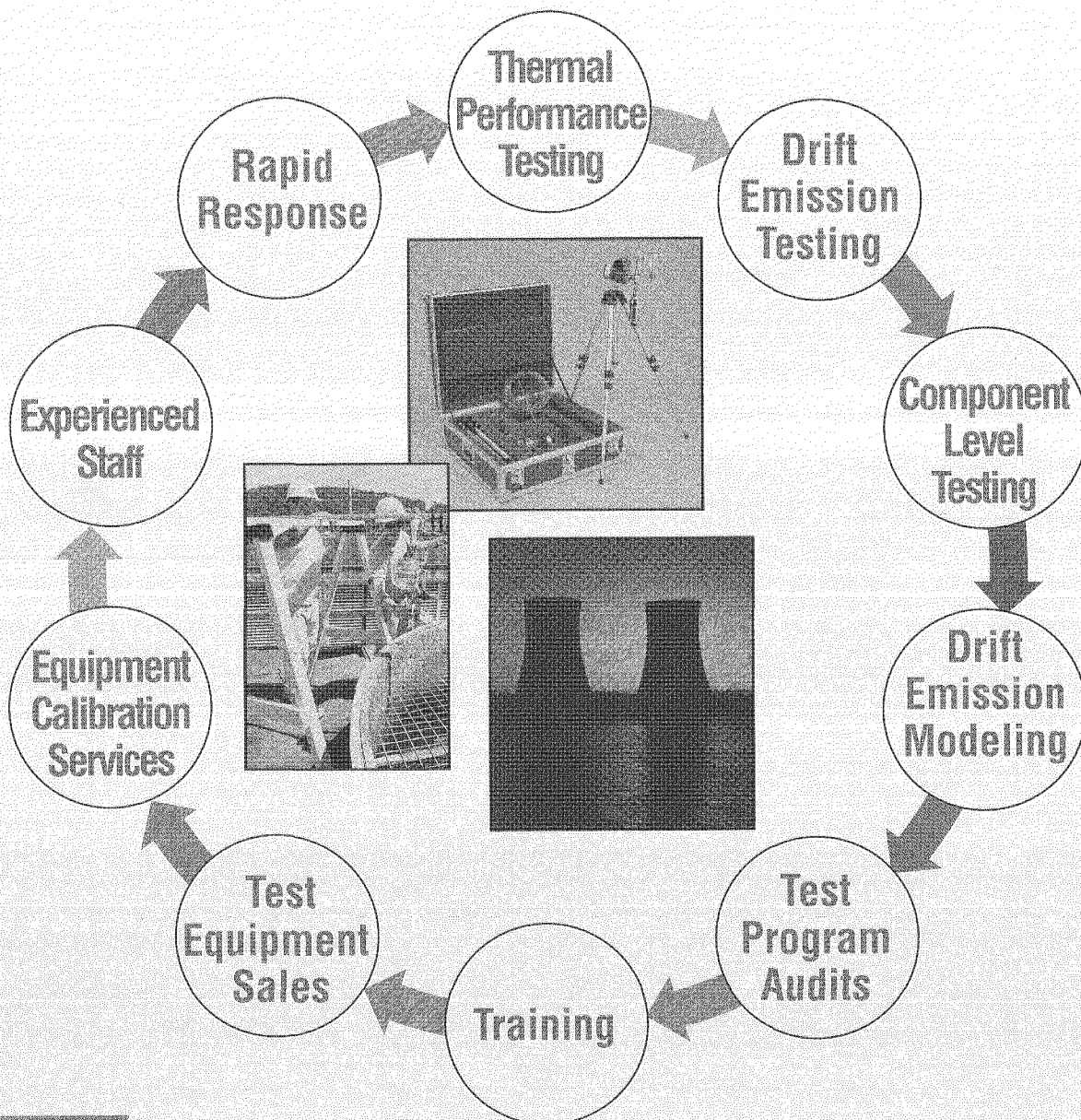
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2–20 ppm are used depending on the type of program used and the water chemistry conditions.

Phosphonates used as calcium carbonate scale control agents also act as corrosion inhibitors at proper dosage levels. Again, they are forming calcium complexes at the cathode. In order for them to work calcium must be present in the water. Cathodic inhibitors that rely on calcium do not work in soft water because they need the calcium to form a complex.

There is a little bit of reaction but not significant at the anode and typically with a phosphonate like HEDP it is necessary to have about 6–10 ppm active, more than you would normally use for calcium carbonate inhibition, in order to have sufficient amount to be a good corrosion inhibitor. Effectiveness is going to vary depending on the hardness of the water, the pH of the system and the amount of iron in the circulating water.

Zinc is traditionally one of the most popular cathodic inhibitors. Zinc doesn't rely on calcium concentration so it can be used in soft water. Zinc forms a hydroxide, zinc hydroxide precipitant at the cathode as a direct result of the hydroxyl ions formed by the corrosion cell. The problem is that when the pH gets to about 8.3 the solubility of zinc is almost zero because at 8.3 free hydroxyl ions can exist in the bulk water. So you have to be very careful. In programs that operate at higher pHs there are zinc-stabilizing polymers just as there are phosphate-stabilizing polymers that allow the use of zinc. Depending on the pH of the system, anywhere from 0.25 ppm to 3 ppm of zinc might be used in the system.

One of the things to look at is a pH buffer. If we maintain the pH at a higher level, all of the anions are going to be acting to help, as cathodic inhibitors, all of the cations in the water. You can also use

buffers such as borax (not used typically in cooling towers but is done in closed systems) to raise the pH up to the range of 9.5–10.0, which is the least corrosive condition for carbon steel.

Nitrite is another inhibitor typically not used in cooling towers because high concentrations are required, which becomes expensive when you have blowdown. It is also an excellent nutrient for microbiological activity, something to be avoided in the cooling towers. It is often used in closed systems to control corrosion where makeup is low. Typically at 500–1000 ppm you have to watch out for microbiological activity. It also provides an oxidative potential to help molybdate work on systems that don't have a lot of oxygen in them, it's an anodic inhibitor that works with the corrosion products at the surface.

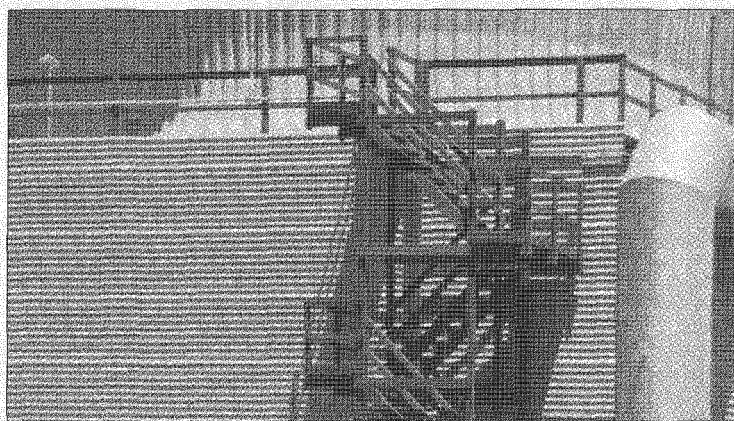
Molybdate does not act the way chromate does. Chromate is a self-oxidizing inhibitor. Molybdate requires an oxidative potential. It is much more like orthophosphate in that manner but it is complexing at the anode just like phosphate and chromate. Sometimes if there are corrosion products on the surface it has some ability to penetrate through the porous deposit to get to the bare metal and help inhibit corrosion.

In closed water systems it is not necessary to make up a significant amount of water so it is possible to use high concentrations of corrosion inhibitors. In addition, with the low makeup water the ion buildup found in cooling tower water does not become a factor in closed systems.

Aromatic azols are organic chemicals that are used as corrosion inhibitors on copper alloys. They are a film forming inhibitor that reacts with cupric oxide to form a surface film. You have to be careful with oxidizing biocides because they can attack the film and cause

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